THE RESULTS OF DIVISION OR RESECTION IN THE NECK OF THE PNEUMOGASTRIC AND PHRENIC NERVES.[1]

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PNEUMOGASTRIC NERVE.

THAT Galen was acquainted with cases of injury to one or both the recurrent nerves after excision of goitrous tumors and the consequent aphonia may be evidenced by the following quotation:

> "Quum ergo ex cervice quidam strumas in profundo sitas excideret ac deinceps, ne secaret aliquod vas, membranas non specillo cæderet sed unguibus evelleret, imprudens ob ignorantiam simul recurrentes nervos distraxit; atque hoc facto puerulum liberavit ab strumis, sed mutum reddidit. Quidam alius in alio puero sectionem faciens ipsum similiter semi-mutum reddidit læso videlicet dumtaxat nervo."[2]

During the present century vague references have been made by a number of writers to cases under consideration,—as, for instance, by Swan,[3] where, as the result of some disease of the pneumogastric trunk, there were during the life of the patient dyspnœa, purring respiration, and polyphagia. In this case upon autopsy both vagi, particularly the left, were found to be affected. In another case, reported by Bignardi,[4] where polyphagia was the most striking feature, the vagus was found to be involved in a number of small neuromata, or, at least, tumors which at that time went by that name. It is, of course, evident that the symptoms due to pneumogastric lesion must vary largely, according to the exact height of the same,—that is, according to whether the main trunk or only some of its branches are involved. Wounds of the pneumogastric from stabs and bullets appear to have been very rare, which Stromeyer[1] ascribes to the protection of the nerve-sheath and mobility of the same. It is interesting that Fearn has reported a case where, as the result of a stab-wound by a knife, the vagus and the carotid were both injured. The patient lived eleven weeks, during which he suffered from dyspnœa and dysphagia with frequent vomiting.[2] Stromeyer saw one case of crushing of the left nerve, where the gunshot canal passed completely through the neck back of the carotids. In this case, from the instant of injury respiratory sounds were lacking in the left lung, and did not recur. Upon autopsy it was found that the nerve had been pressed back against the vertebral column, and its sheath contained a milk-like fluid.

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[1] Read before the American Surgical Association, May 30, 1895.

[2] Opera omnia, ed. Kühn, Lipsiæ, 1824, T. VIII; De locis affectis, Cap. VI, p. 55.

[3] Treatise of Diseases and Injuries of Nerves, London, 1834, p. 170.

[4] Revue Méd., 1831, T. II.

(Query: Could the thoracic duct have been injured?)

Blanke[3] observed a gunshot-wound of the vagus during the Franco-Prussian War, as the result of which, apparently, pneumonia carried off the patient. Demme[4] has reported three cases of injury to the vagus. The first he observed in Milan, and presented at first slow, deep, snoring respiration with laryngismus and alteration of the voice, and reduced respiratory murmur on the injured side; later, severe asthma and collapse with frequent pulse. Similar symptoms were present in both of the other instances. Two of these patients recovered, the third dying during the second week. In this latter case, autopsy revealed a purulent infiltration of the vessels and nerves on the injured side and a hypostatic pneumonia.

In a thesis published by Deibel in 1881,[5] he has collected seventeen cases by various reporters of injuries to the vagus during operation. Widmer[1] has summarized these and added two more, both occurring in the practice of Kappeler in Münsterling.

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[1] Maximen, Second Edition, p. 116.

[2] Provincial Medical and Surgical Journal, November 7, 1848.

[3] Dissertation, Göttingen, 1871.

[4] Allgemeine Chirurgie der Kriegswunden, 1861, Band XI, p. 83.

[5] Ueber die Traumatische Vagus Paralyse, München.

It is certainly worthy of note that in most of the reported cases there were no symptoms directly attaching to the division of the vagus. Reports of disturbance, either of respiration or circulation, are relatively very infrequent. Considering now the particular influence of this nerve upon the various organs which it supplies, we may profitably study for a few moments the main results of its division.

So far as the larynx is concerned, it, of course, will make a difference whether the trunk be divided above the separation of the superior laryngeal nerve or below ; again, whether the recurrent nerve be divided. The majority of reported cases seem to concern those in which, with the tumor situated on the side of the neck, the main trunk could be divided below the separation of at least the superior laryngeal. This superior laryngeal is given off at the lower end of the gangliform plexus, about a quarter of an inch beneath the jugular foramen, and, leaving the main trunk, passes between the internal carotid and the pharynx to the larynx, and is so far separated from the vagus itself that even in extensive extirpations it is seldom injured. It is to be regretted that in most of the reported cases accurate laryngoscopic examinations, as well as accurate data concerning the condition of the voice are lacking; and there are not statistics enough on which to base any very accurate statements. So far as I know, not one of these cases really lost the voice, and some of them were scarcely more than temporarily hoarse.

As more than one neurologist and physiologist has remarked, there is reason to wish for an entire and painstaking review of the subject of the innervation of the oropharyngeal and laryngeal muscles, since the nerve-supply to the epiglottis does not seem yet to be definitely settled. Leaving this question, however, to the anatomist, it is of surgical interest to know that in scarcely any of the reported cases has there been such disturbance of deglutition as to make it appear that the muscles of the epiglottis have been paralyzed. All of which, then, would look as though its muscles were supplied from the superior laryngeal source. It was said in one of Kappeler's cases that for a short time after the operation there seemed to be spasmodic contracture of the epiglottic muscles, which, however, passed away.

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[1] Deutsche Zeitschrift für Chirurgie, Band XXXVI, 1893.

R. Wagner made a number of experiments upon animals to elucidate the functions of the laryngeal nerves. He divided the recurrent, for instance, and found in every instance a median position of the vocal cord on that side. After double division, the cords assumed the median position for a few days, after which they took the cadaveric position, assuming it more slowly in older animals than in the young.[1]

The effects upon the lungs of pneumogastric division were studied at a time much prior to that when its laryngeal effects began to be observed. Valsalva[2] was the first who described the effect upon the lung of double division, although concerning the reasons for the same he was entirely in the dark. Since Valsalva, Morgagni, Longet, and others have concerned themselves with the same problems, until, finally, Traube[3] showed that along with paralysis of the adductors of the cords there was also paralysis of the œsophagus, with entrance of material which should pass down the œsophagus, and consequent pneumonia of a peculiar type. It has also been shown that the consequent lesions in the lung are very uncertain, and seem to be due in large measure to accident, not being constant results of double vagotomy. Frey came to these conclusions: (1) that the majority of cases survived operation; (2) that a certain proportion died after an indefinite time; and (3) that the cause of death was obscure, but that it certainly was not necessarily due to lesions of the lungs, nor to disturbances of nutrition. Some of these animals became emaciated, while their hair became coarse and fell out. In connection with these experimental results, the consequence of unilateral division of the vagus in man is not without interest. In Billroth's first case there were found in the lungs numerous circumscribed foci of red hepatization, which led Billroth to make this remark, " It is certainly of interest that the majority of these cases in mankind terminate fatally, although in dogs and animals it seems to have but little effect." Three years later, however, Billroth had another case of sarcoma extirpated from the neck with necessary resection of the vagus, which terminated successfully. Inasmuch, however, as in his first case it was necessary to make temporary resection of the lower jaw, and to remove a portion of the pharynx, as well as of the velum palati, as the result of which considerable blood ran into the lungs, it is perhaps easier to ascribe death to the combination of circumstances than to the mere division of the nerve. In Sawostitzky's case the patient manifested a double pneumonia, which is not sufficiently explained by anything contained in the case report at hand. In Labat's first case, also, we are told that there was considerable inflammation of the lung, although in the case report itself there is nothing to indicate upon what ground this was diagnosed,—in fact, all details are lacking. In Roux's fatal case, where the patient died on the sixth day of meningo-encephalitis, the lung complication does not seem to have appeared at first, and consequently was not primary. From a study of case reports, then, as well as from comparison of experimental results, it would seem of great importance to emphasize the fact that, although bronchopneumonia frequently results from bilateral division of the vagus, it is not necessarily due entirely to such nerve lesion, since in the lung corresponding to the injured nerve we find, not those conditions that we are often taught to expect,—namely, serous effusion, etc.,—but evidences of normal blood pressure and no œdema. In none of the other cases on record, aside from those above mentioned, is there significant proof of real paralysis of vaso-motors, nor of those vaso-motor fibres which the pneumogastric is supposed to contain.

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[1] Virchow's Archiv, Vol. CXX, p. 457, and Vol. CXXIV, p. 217.

[2] Epis. Anat., Vol. XIII, C. 30.

[3] Beiträge zur Pathologie und Physiologie, Berlin, 1871, Band I.

In a few only of the published cases has there been any immediate disturbance noted as following the nerve division, and most of those which were described could be explained upon some other cause, either from pressure of the tumor or some accident during operation. This is proven, for instance, by one of the cases in which the pleural cavity was opened, by which respiration was materially disturbed. All this disturbance, however, subsided immediately after tracheotomy,—all of which can be explained without reference to the vagus.

Cases of unilateral division of the phrenic, or of injury to the course of the phrenic,—as, for example, in fractures of the cervical vertebræ,—indicate that paralysis of the diaphragm, or at least of one-half of it, puts the patient in immediate danger of life, and also compels the other accessory inspiratory muscles to do an enormous amount of compensatory work. In Kocher's second case there occurred on the second day after the operation, without recognizable disturbance in the lungs, a severe dyspnœa, which was ascribed to a serious secondary hæmorrhage. A curious phenomenon was noted in Roux's case: whenever the fingers were pressed deeply into the wound, violent coughing ensued, which would make it appear that some sensory nerves or unduly sensitive nerve-fibres had been exposed. Comparing the information that may be gathered from all sources, surgical and experimental, we may say that with the exception of more or less vocal paralysis or hoarseness there is no definite disturbance of the respiratory apparatus which can be ascribed with any certainty to injury to the pneumogastric, nor which we have any definite reason to fear.

Concerning the influence of the vagus upon the rhythmical contractions of the heart, it would appear, from the studies of Schiff and Moleschott, that there run within this nerve certain fibres having an inhibitory influence upon the cardiac ganglia. Eichhorst[1] has shown by numerous experiments upon birds that after double division of the vagus an acute fatty degeneration of the heart is the result, which is directly due to the paralysis of certain trophic fibres contained within its trunk. In the smaller quadrupeds the condition is similar, but less marked. Consequently, he concluded that animals died after double vagotomy because of consecutive heart changes. It is of greater importance to remember that Eichhorst also found the same thing to occur after unilateral division, as well as that he corroborated Arloing and Tripier in holding that the right vagus had more to do with the innervation of the heart than the left. This may have been the condition of the heart in Sawostitzky's case, although he was inclined to ascribe it to other causes. Studying case histories, however, we come to the conclusion again that the equality and frequency of the pulse is practically uninfluenced by pneumogastric division, and that no really serious disturbance has ever been really due to such accident.

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[1] Die Troph. Beziehungen der Nervi Vagi zum Herz, Berlin, 1879.

The influence of the vagus upon the digestive apparatus is interesting in a physiological sense; but that which more particularly interests us as surgeons is the possible interference with the act of swallowing, since the recurrent nerve sends motor fibres to the œsophagus and to the inferior constrictor of the pharynx. Studying the case histories, however, we again find that notable disturbances of deglutition have been extremely rare, and that division of the nerve has apparently exerted no lasting influence upon, nor disturbance of, this important function. One of Kappeler's cases complained during the first two days of pain upon swallowing; but this was probably in no sense connected with the vagotomy, since almost any patient who has sustained a severe operation upon the neck will make the same complaint. Finally, the influence of this nerve division upon the general economy may be briefly studied. Frey and others have stated that certain animals—rabbits, for example—died after unilateral vagotomy without the occurrence of definite lesions in any single organ. How much this may have to do with surgery is an open question.

Schou[1] has advised that when one discovers that he has njured the vagus or recurrent nerve he should make immediate tracheotomy, and then should tampon the trachea above the opening, in order that he may with certainty prevent the aspiration pneumonia, to which, rather than to division of the nerve, death may be due. The aspiration of irritating material from the mouth or pharynx is more likely to occur in patients who are semiconscious or who are in collapse than in those who are quite in possession of their usual senses. While this difference is worth remembering, it certainly is not necessary to always carry it out, since there is, perhaps, as much danger of septic disturbance from the tracheal wound itself as from the pharynx above. Widmer[1] has also raised the question whether, when we have to deal with extensive and malignant tumors of the neck, especially with those which are producing severe pressure symptoms, it would not be wise to substitute simple tracheotomy for more radical and severe measures. To be sure, to do this will be to acknowledge the helplessness of the surgeon, but will probably tend to the prolongation of the life of patients. Thus, Braun has reported seventeen tracheotomies in malignant strumas. But, unfortunately for Widmer's suggestion, even in these cases dyspnœa was not necessarily relieved, and only one of these patients lived so long as twelve days; and in this instance dyspnœa was extreme, and death occurred from suffocation.

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[1] Om Behandlingen af de Traum. Vaguslaesionen med Permanent Tamponade af Trach., Nord med. Arch., Band XVIII, No. 5, 1886.

It has been stated by Flint that after section of the pneumogastric digitalis has been found to have no effect upon the heart's action; while H. C. Wood has observed that under like conditions cathartics would not produce purgation. These statements have been made the subject of experiment by C. S. Jones,[2] and have been in the main corroborated by him. It was also stated by Flint that after section of both pneumogastrics death always resulted in from one to six days unless the cord ends reunited. The experiments of Jones and of numerous other observers have disproved this statement. Furthermore, that after the lapse of a number of days the suspended normal functions were gradually restored, and that digestion of food, nevertheless, occurred; while heart-beats have been known to come down from 210 to 120.

I am indebted to my friend, Professor Pohlman, for the statement that after division of the pneumogastric in dogs he has found round ulcers in the stomach with such regularity that he now expects them as the usual effect of such nerve section. I am not aware that anything of this kind has been noted clinically, and do not know exactly how to explain it, save possibly upon the hypothesis that the pneumogastric has more to do with the trophic changes of the stomach in the dog than in the human being.

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[1] Loc. cit.

[2] Medical Press of Western New York, 1888, Vol. III, p. 184.

Guttman[1] has particularly called attention to the frequency with which large tumors of the cervical lymphatics, the thyroid, the peribronchial lymphatics, aneurisms, etc., may produce a compression paralysis of the pneumogastric, by pressure either in the neck or within the thorax. This paralysis is very rarely bilateral, and when it is so involves usually only the inferior laryngeal nerves. Longet[2] collected a considerable number of cases of this general character from literature; and these cases were added to by Montault, Hankel, Ley, Kyll, and others. In a case reported by Gaubric and referred to by Longet, both inferior laryngeal nerves were included within a tumor springing from the thyroid. Thereby a peculiar character was given to the respiration. Such incidents have become more and more frequent as men have learned better to watch for them or to appreciate them. Within my own experience I have repeatedly seen patients suffering, and eventually dying, from complications evidently connected with implication of some portion of the pneumogastric in primary or recurring malignant tumors. A number of times I have seen evidences, apparently unmistakable, of pressure by infected bronchial lymph nodes, which are the more painful to observe because of the utter helplessness of the condition. Heine[3] reported a most typical instance demonstrating the inhibitory action of the pneumogastric. His patient suffered from paroxysms of indescribable anxiety and apprehension, much like those produced in angina pectoris, in which the heart pulsations would drop to one-fourth or one-sixth of their regular number, to resume the usual pulse-rate on the expiration of the attack. Rokitansky made the section, and found the right phrenic nerve and cardiac branches, as well as the ascending cardiac branches of the left pneumogastric, involved in a small tumor. Blandin is stated by Longet to have had to do with an analogous case in several respects, in which the vagus was found to be the site of a very small tumor, arising from its own tissue, apparently primary in the neurilemma, and leading to atrophy of the trunk below the tumor.

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[1] Virchow's Archiv, Vol. LXXIX, p. 51, et seq.

[2] Anat. et Phys. du Syst. Nerv., Vol. II, 1849.

[3] Müller's Archiv für Physiologie, 1841, p. 236.

Two or three other conditions have been noted by Guttman[1] which, perhaps, are worth a reference here. For instance, Bignardi found on the post-mortem examination of a woman who had died of some lung disturbance, and whose last weeks of life were characterized by a most ravenous appetite, that both pneumogastrics were involved in a number of small reddish neuromata, which had about the size of the ganglia on the posterior roots of the spinal nerves.

Swan[2] reported also the case of a patient who, in spite of apparent healthy condition of the lungs, suffered intensely from dyspnœa, and who had also a ravenous appetite, which he was apparently never able to completely satisfy. When he vomited, it was found that the stomach would reject food apparently unchanged, although it might have remained there several hours. In his case both pneumogastrics were found atrophied, especially the left one.

Furthermore, Longet refers to an observation of Johnson's, who has reported a case of softening of the medulla and compression of the nucleus of origin of the left vagus by an aneurismal dilatation of the left vertebral artery. In this instance the patient lost all sense of hunger and thirst. From which contradictory instances, above noted, it would appear impossible to draw exact conclusions as to the precise influence of the vagus upon the sensations of hunger, thirst, and repletion.

In certain text-books and treatises I have found certain paragraphs bearing on this subject which are, perhaps, worthy of reproduction, although they are not given in any particular order, nor do they have particular bearing on any one case. They are quoted here because I have been anxious to get together an epitome of all the literature on the subject.

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[1] Virchow's Archiv, Vol. LXIX, p. 64.

[2] Treatise on Diseases and Injuries of Nerves, London, 1834, p. 170.

Chelius[1] quotes a case reported by Hennen, of an officer who was wounded in the neck about an inch above the origin of the sterno-cleido-mastoideus, the ball passing into the thorax and leaving no trace of its route. He lost an enormous quantity of blood, his left arm hung nearly lifeless, pulse 120, and the following day he spit up frothy blood copiously, and had severe and almost constant retching with spasm of the throat and hiccough. On the third day the dyspnœa was almost suffocating, and nerve symptoms were also serious. On the fourth day his voice was lost until the sixth. On the thirtieth day, after severe spasmodic bilious vomiting, speech was again temporarily affected. Some six weeks later he went home, where he continued to improve. This may have been an injury to the pneumogastric or some of its branches.

Chelius has also noted the fact that injuries of the pneumogastric cause loss of voice, spasmodic symptoms, and sometimes death. Injury of the recurrent nerve also causes loss of voice, which may occur subsequently. He states that injury of the laryngeal nerve is fatal from arrest of breathing, and that this is the particular branch whose section so quickly produces death in animals.[2]

Luecke[3] has alluded to the fact that certain fibres of the large nerves may be involved in a tumor without compromising the activity of the entire nerve. The fact also of the slow growth of the tumor seems to have an important influence, since the nerve apparently becomes accustomed to this encroachment upon its integrity.

Billroth[4] makes this statement: "All cases of unilateral division of the vagus in the human being appear to have terminated fatally, although these operations in dogs and larger animals have produced but little disturbance and are never fatal."

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[1] System of Surgery, translated by South, Vol. I, p. 480.

[2] See Pye, Aufsätze und Beobachtungen aus der gerichtlichen Arzneiwissenschaft, Saml. VII, p. 185.

[3] Geschwülste, Pitha und Billroth, Handbuch, p. 36.

[4] Archiv für klinische Chirurgie, Vol. II, p. 655.

Deibel[1] calls attention to the property possessed by nerves and vessels of resisting the encroachments of tumors, just as Langenbeck[2] had much earlier pointed out. This is fortunate, since the vagus and phrenic nerves remain apparently uncompromised by a degree of pressure which *a priori* it would hardly seem as if they could resist. They permit, moreover, considerable displacement without interference of function. Billroth[3] has shown that of all the important structures in the neck the jugular vein is most easily displaced, and is usually found at the greatest distance removed from its proper position; also that its wall is more often found adherent to the tumor surface than is that of the artery or the substance of the nerve.

Fischer[4] says, " Isolated injuries of the cervical nerves one would hold for scarcely possible, were it not for the character and composition of certain gunshot wounds of the neck. Altogether, they are not frequent, and their symptoms are never so clearly developed that a precise diagnosis can be made. Death is not the invariable result. Balls have wounded the pneumogastric more than once. Stromeyer has reported a case where the nerve-trunk behind the carotid was injured by a ball which crushed a cervical vertebra, while the right nerve was only slightly involved; in consequence of which respiratory murmur was lacking on the left side. In three instances the injury has been suspected because of slow, deep, snoring, difficult respiration, laryngismus, hoarse voice or loss of voice, lessened respiratory murmur, dyspnœa, and fainting attacks. In two of these instances the patients recovered, while one died in the second week of pneumonia and purulent infiltration. These are reported by Demme. Schueller holds that by pressure upon the nerve-trunk of the cicatricial tissue filling such a gunshot canal, a slowing of the heart's action may be produced. Fearn has seen difficulty in swallowing and fainting attacks, followed by death in three weeks, as the result of a division of the pneumogastric and the carotid; while at the end of the upper extremity of the nerve which was divided was found a neuroma."

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[1] Deibel's Thesis.

[2] Beiträgen z. chir. Path. der Vennen, Archiv für klinische Chirurgie, Vol. I, p. 62.

[3] Chir. Klin., Wien, 1870, p. 76, Hals.

[4] Deut. Chir., Lieferung 34, Krankheiten des Halses.

Gross:[1] "The division of the phrenic nerves is nearly instantaneously mortal, and the same is true of division of the pneumogastric nerves, although this has occasionally been denied. If only one of the pneumogastric nerves is left, the patient may survive, . . . or he may perish from the effects of congestion and inflammation of the lungs."

Conner:[2] "To injury of the pneumogastric was attributed by Larrey the intense thirst which is at times experienced by the subjects of œsophageal wounds.

"Occasionally several of the important nerves are simultaneously injured, as the case reported by Stromeyer, in which the phrenic, pneumogastric, middle ganglion of the sympathetic, and the descendens noni were wounded, together with the larynx and pharynx."

According to Dupuy, animals may live for some time after division of both pneumogastrics, providing the trachea be opened below the larynx; while if the opening be not made, the animal dies on account of paralysis of the muscles controlling the glottis.[3]

THE PHRENIC NERVE.

The phrenic has already been incidentally mentioned in several of the cases above epitomized, and in some of the general statements already made in this paper. Consequently it calls for but little further and separate mention.

Fischer[4] states that "when this nerve was included in the ligature of the subclavian outside of the scalenus there set in immediately after the operation a continuous violent cough, which lasted until the patient's death, on the fifteenth day. The nerve itself was found uninjured, but its neurilemma was markedly inflamed or congested. This was the condition under observation in a case reported by Bransby Cooper, where the mistake was made of including the nerve within the ligature.

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[1] System of Surgery, Vol. II, Fifth Edition, 1872, p. 423.

[2] Gunshot Wounds, International Encyclopædia of Surgery, Vol. II, p. 183.

[3] Jour. de Méd., par Le Roux, etc., Vol. XXXVII, p. 351; Meckel, Handbuch der gerichtlichen Med., Halle, 1821, p. 172.

[4] Loc. cit., p. 123.

Agnew[1] states that he has in his possession a preparation in which the entire phrenic nerve passes over the third part of the subclavian artery, so that it might be damaged at a point where it would scarcely be looked for. The details in Bransby Cooper's case are not explicit enough to show whether this anomaly obtained in that instance.

Ericsen[2] says, "The division, however, of the respiratory nerves on one side only . . . would, in all probability, be fatal in man by interfering with the proper performance of the respiratory act. In a case with which I am acquainted, where the phrenic nerve was divided during ligation of the subclavian artery, death resulted in a few days from congestion of the lungs."

Demme has observed three cases of injury to these nerves. It is stated that two recovered, while the third died of pneumonia.

Riedel[3] has published a case of resection of the left nerve during extirpation of a tumor. No symptoms were discoverable at the time. Patient died on the fourteenth day, and on autopsy purulent bronchitis on this side was noted.

Hutin[4] wounded the phrenic in making ligature of the subclavian artery.

Hueter-Lossen[5] say that paralysis of half of the diaphragm puts life in immediate danger. This is evident, not only from observation of injuries to the phrenic itself, which are rare, but from injuries to the roots of the nerves in the spinal cord, which determine practically always a fatal termination. These latter may be produced by injuries from the fourth cervical vertebra down, or by degenerative processes spreading from below upward. They are always indicated by paralysis of this principal muscle of respiration, the accessory muscles having been already more or less paralyzed, probably completely. Diaphragmatic paralysis is always easy to determine, since by it alone is inspiration prevented under ordinary circumstances.

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[1] Treatise on Surgery, Vol. I, p. 321.

[2] Treatise on Surgery, Eighth Edition, 1884, Vol. I, p. 785.

[3] Berliner klinische Wochenschrift, 1883, p. 543.

[4] Quoted by Lafoure in Dict. Encyl. de Sci. Méd., Third Series, Vol. X, p. 707, article Sous Clavière.

[5] Chirurgie, Vol. II.

Finally, the suggestion made by Wyeth[1] that when the pneumogastric, hypoglossal, or other important nerves have been divided, the ends should be brought together by a delicate silk suture, may possibly be put into practice with the same success attending nerve suture in other trunks. The suggestion, at least, is a valuable one, and is given here for what it may be worth. (*Vide* Case 47, Table II.)

The following quotations may also be introduced here, having more or less relevancy to matters already spoken of:

" International Encyclopedia of Surgery," Vol. v. p. 107; Nancrede: " Aphonia, dysphagia, dyspnœa, with contraction of the muscles accessory to respiration, and more or less paralysis of the pharynx, œsophagus, and stomach were the main symptoms presented by a patient who recovered from a brain wound in which the glossal, pharyngeal, pneumogastric, hypoglossal, spinal accessory, and suboccipital nerves were divided by the thrust of a lance."

Boinet[2] reported that he in one case was obliged to carefully separate the vagus from the carotid for the purpose of ligating the latter. He noted that each time the nerve was disturbed vomiting set in, without, however, any disturbance in respiration.

" Heath's Dictionary of Practical Surgery,"—" Gunshot Wounds," subheading, " Gunshot Injury of Nerves." American Edition, 1886, p. 642.—" The pneumogastric has been sometimes divided in the neck, generally with an immediately fatal result and wounding of the adjacent vessels. Otherwise, the respiration becomes slow and labored, the voice is lost, the pupil on the injured side contracted, and pneumonia supervenes."

Duplay and Reclus (*Traité de Chirurgie*, Vol. v; Walther,

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[1] Wyeth's Text-Book, 1887, p. 444.

[2] Gazette des Hôpitaux, No. 102, p. 413.

p. 675): Injury to the pneumogastric may be made more probable by abnormal situation in front of the carotid, an anomaly alluded to by Le Dentu,[1] and actually encountered by Janelle,[2] during the course of a thyroidectomy. Walther emphasizes the fact that sudden disturbance from injury or division of the nerve is less likely to occur if it has been for some time accustomed to pressure by tumor or by some other lesion.

Finally, the following arrangement of possible results of lesions of the pneumogastric may be reproduced from Giordano:

The Pneumogastric may be involved Primarily in :—
  Diphtheritic neuritis.
  Mycotic neuritis (kakké).
  Post-typhoid, etc., neuritis.
  Toxic paralysis (as after use of iodine for goitre, etc.).
  Tabetic paralysis.
  Bulbar hæmorrhages, tumors, etc.
Secondarily in :
  Phlegmons of neck.
  Pericarditis.
  Periaortitis.
  Tumors,—bones of base of skull, etc.
  Tumors,—side of neck.
  Tumors,—thyroidal.
  Tumors,—mediastinal, lungs, etc.
  Aneurisms, aortic and innominate.
  Pleuritic exudates,—apical.
  Pericardial exudates.
  Peritracheal lymphatic tumors.

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[1] Bulletin de la Société de Chirurgie, 1860, May, p. 280.
[2] International Encyclopedia of Surgery, Vol. v.

TABLE I.—ACCIDENTAL INJURIES TO THE PNEUMOGASTRIC.

No.	Reporter.	Result.	Remarks.
1	Fearn.	D.	Stab-wound; carotid divided also; vomiting; glottic œdema; aphonia; death, eleventh week. (Provinc. Med. and Surg. Jour., 1847, Sept. 8.)
2	Stromeyer.	D.	Bullet-wound; right vagus blown to pieces; left vagus crushed; death after third week. (Pitha-Billroth, III, I, 4.)
3	Demme.	R.	Bullet-wound; recovery.
4	"	R.	Bullet-wound; recovery.
5	"	D.	Bullet-wound; death in two weeks; pneumonitis. (Pitha-Billroth, l. c.)
6	Verga.	D.	Bullet-wound; death in three weeks. (Tamassia, Della azione del Pneumogastrico, etc.; Riv. Sperimentale di Freniatria e di Med. Legali, 3, p. 229, *et seq.*)
7	Hennen.	?	Bullet-wound; aphonia; result not given. (Fischer, Deutsche Chir., Lief. 34, p. 17, S. 125.)
8	Beck and Stromeyer.	D.	Bullet-wound; injury also to phrenic, cervical, ganglion, and hypoglossal; respiration slow; death fifth day from laryngismus. (Fischer, p. 125.)
9	Peyrot.	?	Bullet-wound; no details. (Walther, in Duplay and Reclus, Vol. V.)
10	Montauld.	D.	Trauma; fracture of left cornu of hyoid with pressure on vagus; dysphonia; dysphagia; dyspnœa; death in twenty-four hours. (Eulenberg, Art. Erkrank. d. Nervus Vagus, Real Encyclopædie, Band XX.)
11	. . . .	D.	Suicidal cut-throat attempt in woman of thirty-six years. Right pneumogastric divided; no marked symptoms; no post-mortem appearances. (Brit. Med. Jour., 1856, June 13.)
12	Bowlby.	D.	Fracture of base of skull, with laceration of eighth pair on left side. Post mortem showed this condition, and that left lung was in condition of solid œdema and airless. (L. c., p. 115.)
13	Burggrave.	D.	Patient run over by wagon. Usual case, traumatic compression of vagus and sympathetic; death soon after. Autopsy showed an extravasation of blood completely surrounding these two nerves. (Union Méd., 1852, p. 531.)
14	Savory.	D.	Case of abscess. Large portion of pneumogastric nerve also destroyed in its course through the cavity. The two ends of nerve were found free in upper and lower part, a portion being wanting; no very obvious effect of this destruction. During last two or three days of life pulse very rapid, but might otherwise be well explained. After death left lung presented no characteristics that could be especially associated with the lesion of nerve. (Trans. Royal Med. and Chir. Soc., Vol. XLIV, p. 28.)
15	Riegel.	D.	Post mortem of man of fifty-three years. Chief symptom extreme rapidity of pulse,—164. Left vagus, just below recurrent branch, embedded and firmly incorporated in enlarged bronchial node. (Berliner klin. Wochen., 1875, August 2.)

Table II.—Injuries to the Pneumogastric during Operations upon the Neck.

No.	Reporter.	Result.	Remarks.
1	Labat.	R.	Female of twenty-eight years. Extirpation of cervical cancer; resection of common carotid, internal jugular, and right vagus; pulmonary paralysis on left side; recovery. (Testi, Broussai's Annales, 1834.)
2	Roux.	D.	Male, forty-five years. Same kind of case. Died on seventh day. (Prov. Med. and Surg. Jour., 1847, September 8.)
3	Roux.	D.	Cancer of neck; vagus tied with carotid, but subsequently liberated; death in one-half hour. (Tamassia, l. c.)
4	Billroth.	D.	Male, thirty-four years. Sarcoma of neck; common carotid tied and vagus resected; respiration slackened; dysphagia; death in three days; pulmonary œdema, etc. (Arch. f. klin. Chir., Vol. II.)
5	Billroth.	R.	Male, thirty years. Lymphoma of neck; resection of vagus and internal jugular; paralysis of vocal cord; recovery. (Chir. Klin., Zurich, 1860–67.)
6	McClellan.	R.	Two inches of the vagus exsected from enlarged parotid gland below angle of jaw; apparently not much inconvenience to respiratory or other functions. Left wound open several days to let other surgeons inspect, on account of being an unprecedented result. (Am. Edit. Velpeau's Operative Surg., Vol. II, p. 427.)
7	Robert.	R.	Male patient. Vagus included in ligature of carotid. Voice instantly became hoarse; fainted; recovered shortly; voice not regained for six months. (Gaz. des Hôpi., 1863, No. 102, p. 413.)
8	Chassaignac.	R.	In 1849, pneumogastric included in ligature of common carotid; respiration and deglutition not disturbed, but voice immediately extinguished. (Bowlby, Injuries and Diseases of the Nerves.)
9	Esmarch.	D.	Male, forty-five years. Sarcoma of parotid; common carotid and internal jugular injured with the vagus; death in six weeks. (Arch. f. klin. Chir., Vol. XX, p. 611.)
10	Esmarch.	D.	Male Recurring cancer; resection of three centimetres of involved vagus; death in one week; hæmorrhage and récidive. (Ibid.).
11	Sawostitzky.	D.	Male of eleven years. Lymphosarcoma; resection of common carotid, jugular, and vagus; death in ten hours. (Centralblt. f. Chir., 1880, No. 10.)
12	Sawostitzky.	D.	No details; death. (Ibid.)
13	Schönborn.	D.	Female, twenty-three years. Alveolar sarcoma; resection of carotid and vagus; death in thirty-six hours. (Deut. Zeit. f. Chir., Vol. XIII, p. 394.)
14	Lücke.	R.	Female of thirty years. Cancer of neck; resection of jugular and twelve centimetres of diseased vagus; recovery. (Centralblt. f. Chir., 1880, No. 36.)

TABLE II.—INJURIES TO THE PNEUMOGASTRIC DURING OPERATIONS UPON THE NECK.—*Continued.*

No.	Reporter.	Result.	Remarks.
15	Czerny.	R.	Male, forty-six years. Cancerous goitre; resection of jugular and three centimetres of vagus; recovery. (Deut. Zeit. f. Chir., Vol. XIV, p. 143.)
16	Bardeleben.	D.	Male, fifty-seven years. Cancer of neck; vagus included in ligation of carotid and jugular; death in two hours. (Deibel, l. c.)
17	Langenbeck.	D.	Female, forty-nine years. Cancerous goitre; ligature of carotid and jugular; pleural cavity opened; vagus resected; cyanosis, dyspnœa, and pulmonary œdema; death in eight hours. (Deibel, l. c.)
18	Riedel.	D.	Male of forty-nine years. Goitre; ligature of vessels; vagus divided; pulmonary œdema and putrid bronchitis; death on the fourteenth day. (Berl. klin. Woch., 1883, No. 23, p. 343.)
19	Robert.	R.	No details; vagus included in ligature of the carotid; sense of suffocation; recovery with aphonia. (Tamassia, l. c.)
20	Boinet.	R.	Injury to vagus during ligation of carotid; vomiting, (Eulenberg, l. c.)
21	Kappeler.	R.	Resection of vagus; aphonia; recovery. (Tamassia, l. c.)
22	Mackenzie.	R.	No details; recovery. (Tamassia, l. c.)
23	Jeannel.	D.	Male. Thyroidectomy; no details; death. (Internat. Encyc. of Surg.)
24	S. Cohen.	R.	Division of vagus; vocal paralysis; no details; recovery. (Rénault in Traité de Méd. de Charcot et Pouchard, Vol. IV, p. 1.)
25	Verneuil.	?	Cancer of neck; no details; symptoms rather of injury to sympathetic; result. (Fischer, l. c.)
26	Michaux.	R.	Extirpation of lipoma. While tying its pedicle, vagus was caught; respiration ceased, to be resumed when nerve was released; recovery. (Koenig and Riedel, Deutsche Chir., Lief. 36, p. 109.)
27	Kohos.	R.	Cancer; division of vagus; recovery. (Eulenberg, l. c.)
28	Vogel.	R.	Similar case. (Ibid.)
29	Guida.	R.	Male of forty years. Sarcoma of neck; resection of carotid, jugular, vagus, and hypoglossal; no violent symptoms: recovery. (Riforma Med., 1892, Vol. IV, p. 466.)
30	Mugnaj.	R.	Sarcoma of neck. Disturbance of vagus during operation; pleural cavity opened; no symptoms; recovery. (Gaz. degli Ospitali, 1889, No. 99.)
31	Caselli.	D.	Similar cases but speedy death. (Atti del Third Cong. della Soc. Ital. di Chirurg.)
32	Caselli.	D.	Similar cases but speedy death. (Atti del Third Cong. della Soc. Ital. di Chirurg.)
33	Novaro.	D.	Male, fifty-three years. Cancer of bronchial remains; vagus exposed, and disturbed opposite pulley of digastric. Later, pulmonary œdema, necessitating tracheotomy; death the third day. (Giordano, l. c.)

TABLE II.—INJURIES TO THE PNEUMOGASTRIC DURING OPERATIONS UPON THE NECK.—*Continued.*

No.	Reporter.	Result.	Remarks.
34	Novaro.	R.	Male, fifty-six years. Sarcoma of accessory thyroid; resection of ten centimetres of vagus; no serious symptoms; recovery. (Giordano, l. c.)
35	Marchand.	D.	Angiosarcoma of carotid gland; ligature of carotid and jugular; death from bronchopneumonia. At autopsy found vagus and sympathetic had been removed with tumor. (Centralblt. f. allgem. Path. and Path. Anat., 1892, p. 906, Ref.)
36	Tansini.	R.	Female of twenty-four years. Tubercular disease; resection of vagus; jugular tied; no serious symptoms; recovery. (Latis and Fogliani, Rendiconto Cl. della Cl. Chirurg. di Modena, 1892, p. 41.)
37	Kappeler.	D.	Male of sixty-three years, 1878. Cancer of neck; resection of five centimetres of vagus; death in collapse on second day. (Giordano, l. c., p. 271.)
38	Kappeler.	D.	Male, sixty years, 1890. Cancer of neck; low resection of four centimetres of vagus; death from hæmorrhage and recurrence.
39	Kocher.	R.	1883. Cancer in neck; resection of five centimetres of vagus.
40	Kocher.	D.	Cancerous goitre with paralysis of sympathetic and hypoglossal; resection of these with vagus; death in ten hours.
41	Kocher.	D.	Cancer of œsophagus and glands; resection of vagus, sympathetic, and part of cervical plexus; death on fourth day from hæmorrhage.
42	Rivington.	D.	Division of pneumogastric during ligation of internal carotid; no special symptoms; death from cerebral abscess. At autopsy no special lesions found. (Rep. to Roy. Med. and Chir. Soc., 1885.)
43	Czerny.	R.	Lymphosarcoma of left tonsil extending into pharynx and soft palate. Operation June, 1877. Division of digastric, stylo-hyoid, stylo-glossus, hypoglossal, glosso-pharyngeal, and lingual nerves; recovery. (Beit. z. operativen Chir., 1878, p. 65.)
44	Czerny.	R.	Recurring lymphosarcoma in cervical lymphatics after extirpation of larynx and wearing of artificial substitute. First operation, August, 1878; second, October, 1879, when veins were extensively divided and three centimetres of left pneumogastric excised. Also excision of portion of hypoglossal nerve; no disturbance of pulse nor respiration; death a month later, but from causes connected rather with the malignant disease than from the operation. (Berl. klin. Woch., 1882, No. 26, p. 27.)
45	Mynter.	R.	Melanotic sarcoma of left side of neck, involving parotid region and superior triangle of neck, also lateral region of neck down to clavicle. Operation May 27, 1890. Temporary ligature of common carotid, facilitating removal of tumor. Finally, necessary to exsect a portion of carotid, internal jugular, and pneumogastric, which were embedded in the mass for several inches. Wound partially sutured and packed. Left facial also divided. Death June 13 of cerebral anæmia. (Personal communication.)

TABLE II.—INJURIES TO THE PNEUMOGASTRIC DURING OPERATIONS UPON THE NECK.—*Concluded.*

No.	Reporter.	Result.	Remarks.
46	Harrington.	R.	Complete excision of portion of right nerve during operation for removal of extensive tumor from neck. (Case not yet reported.)
47	Bloodgood.	R.	Divided the pneumogastric by accident during operation on the neck, and, although there was no disturbance noted at the time, made immediate primary suture of the same. Patient recovered without perceptible effect. (Personal communication from Professor Halsted.)
48	Fenger.	R.	Case of division and exsection of the nerve during operations upon the neck. Will be reported in detail by him. Recovered.
49	Fenger.	R.	Case of division and exsection of the nerve during operations upon the neck. Will be reported in detail by him. Recovered.
50	Gross.	?	One case, recalled by Dr. Connor, in which the nerve was divided during operation. Personal communication.

Scanning the cases collected in Table I, we find that out of fifteen instances in which the pneumogastric was accidentally involved in malignant disease or merely in accidental injuries, eleven died and two recovered; while in two instances the result has not been reported. It is, of course, impossible to separate the causes of death so far that one may distinctly state whether death was due to lesion of the nerve-trunk itself or to coincident lesions of other important structures. The fact, however, remains that out of thirteen cases whose results are known, eleven died.

Of the fifty cases included under Table II, we are left in doubt in two instances; while of the remaining forty-eight, twenty-one died and twenty-seven recovered. All of which constitutes a favorable showing, which to the writer seems a sufficient contradiction for statements found in the older works. Here, too, in the fatal cases it is impossible to say that in any instance death was due to injury to the nerve; and there have been included under the deaths several cases where the fatal issue was so long postponed as to constitute valid doubt. Nevertheless, the preponderance of testimony is in favor of the comparative safety of attacking this nerve when involved in disease, and when too much other operating is not necessitated by the condition which has caused the operative attack.

The following list of references is given in addition to those already mentioned in the body of the paper :

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